

AF/IFW

Response Under 37 CFR §41.37  
Application No. 10/644,791  
In Support of Notice of Appeal Dated April 5, 2006  
Paper Dated: June 5, 2006  
Attorney Docket No. 3833-030392



**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES**

Application No. : 10/644,791  
Applicants : Anthony A. Gallo et al.  
Filed : August 19, 2003  
Title : Flame Retardant Molding Compositions Containing  
Group VIA Metal Oxides  
Group Art Unit : 1712 Confirmation No. : 7402  
Examiner : Robert E. L. Sellers Customer No. : 28289

MAIL STOP APPEAL BRIEF – PATENTS  
Commissioner for Patents  
P. O. Box 1450  
Alexandria, VA 22313-1450

**APPELLANT'S BRIEF UNDER 37 C.F.R. §41.37**

Sir:

This Appeal Brief is submitted in support of the Notice of Appeal filed  
April 5, 2006.

I hereby certify that this correspondence is being deposited  
with the United States Postal Service as first class mail in an  
envelope addressed to MAIL STOP APPEAL BRIEF –  
PATENTS, Commissioner for Patents, P.O. Box 1450,  
Alexandria, VA 22313-1450 on June 5, 2006.

Florence P. Trevethan  
(Name of Person Mailing Paper)

*Florence P. Trevethan* 06/05/2006  
Signature Date

The headings used hereinafter and that which is set forth under each heading are in accordance with 37 C.F.R. §41.37(c)(1).

#### **I. REAL PARTY IN INTEREST**

Henkel Loctite Corporation is the Assignee of the entire right, title and interest in the above-identified application, as evidenced in the Assignment recorded August 19, 2003 at Reel 014423, Frame 0698. Henkel Loctite Corporation was merged into Henkel Corporation effective January 1, 2004, and, as such, is the real party in interest in this Appeal.

#### **II. RELATED APPEALS AND INTERFERENCES**

There are no appeals or interferences known to Applicants, Applicants' legal representative or Assignee, which will directly affect, or be directly affected by or having a bearing on, a decision in the present appeal.

#### **III. STATUS OF CLAIMS**

Claims 1-15 and 25-27 are pending in the present application. Claims 16-24 have been cancelled.

Claims 1-15 and 25-27 stand rejected under 35 U.S.C. §103(a) as allegedly being obvious over U.S. Patent No. 6,432,540 to Gallo and Japanese Patent Nos. 11-269347 and 10-212396 in view of Japanese Patent No. 11-100492.

Claims 1-15 and 25-27 stand rejected under 35 U.S.C. §103(a) as allegedly being obvious over JP '492, in view of the Gallo patent and JP '347.

#### **IV. STATUS OF AMENDMENTS**

No amendments to the claims have been made after the final rejection.

## **V. SUMMARY OF CLAIMED SUBJECT MATTER**

The present invention includes a flame retardant molding composition that is substantially free of halogen, antimony and phosphorous, per Para. [0008] of the application as filed. The molding composition includes an epoxy resin, melamine cyanurate and a transition metal oxide of a Group VIA element. Para. [0009].

The present invention also includes a flame retardant molding composition substantially free of elemental halogen, phosphorous and antimony that includes about 4-12 wt.% epoxy resin, 0.1-3.5 wt.% melamine cyanurate, 0.1-2 wt.% tungsten trioxide, 0.001-10 wt.% phenolic hardener and 10-85 wt.% of a filler material, each of these weight percentages being on the basis of the total weight of the composition. Paras. [0020] (amount of resin), [0021] and [0023] (amount of phenolic hardener), [0026] (amount of melamine cyanurate), [0027] (amount of WO<sub>3</sub>), and [0029] (amount of filler). Alternatively, the flame retardant molding composition may include, instead of a phenolic hardener, an anhydride hardener in the same amounts of 0.001-10 wt.%. Para. [0021].

## **VI. ISSUES TO BE REVIEWED ON APPEAL**

1. Whether claims 1-15 and 25-27 are not obvious under 35 U.S.C. §103(a) over U.S. Patent No. 6,432,540 to Gallo and Japanese Patent Nos. 11-269347 and 10-212396 in view of Japanese Patent No. 11-100492?
2. Whether claims 1-15 and 25-27 are not obvious under 35 U.S.C. §103(a) over JP '492, in view of the Gallo patent and JP '347.

## **VII. ARGUMENT**

### **A. Obviousness based on a combination of elements from multiple references must be properly articulated.**

Assessment of obviousness of claimed subject matter requires determining the scope and content of the prior art, ascertaining the differences between the prior art and the claims and resolving the level of ordinary skill in the art. *In re Kahn*, 441 F.3d 977, 985; 78 USPQ2d 1329, 1335 (Fed. Cir. 2006), citing *Dann*

*v. Johnston*, 425 U.S. 219, 226 (1976). Mere identification of the claimed elements in the prior art is not sufficient to establish obviousness. *Id.* There must be articulated "reasons one skilled in the art would have been motivated to select the references and to combine them to render the claimed invention obvious". *Kahn*, 441 F.3d at 986 78; USPQ2d at 1335. See also, *In re Rouffet*, 149 F.3d 1350; 47 USPQ2d 1453 (Fed. Cir. 1998).

**B. The use of JP '492 as a secondary reference with the primary references is inappropriate because there is no suggestion of the desirability of combining their teachings.**

The final Office Action notes that the primary references teach using certain transition metal oxides as flame retardants: tungsten trioxide (Gallo patent at col. 4, lines 35-37) and molybdenum oxide or tungsten trioxide (JP '347, pg. 4, par. 11, lines 1-6 and JP '396, pg. 2, par. 11). None of these three primary references teaches or suggests including an organic flame retardant (such as melamine cyanurate) with the transition metal oxides. The secondary reference of JP '492 is relied upon for supposedly teaching the use of melamine cyanurate together with a metal oxide (NiO, not a transition metal oxide) in order to improve the properties of the resulting composition in addition to fire resistance.

The final Office Action asserts that it would be obvious to include melamine cyanurate with the compositions of the primary references "in order to impart solder thermal resistance". While JP '492 discloses using melamine cyanurate as a flame retardant, it does not teach so doing to impart solder thermal resistance. The Office Action also asserts that "[t]he motivation to incorporate the melamine cyanurate of Japanese '492 into the blends of the primary references is entirely consistent with the objectives thereof". This ability to combine references does not render the resultant combination obvious, unless there is some suggestion for the reason of doing so. *Kahn*, 441 F.3d at 986; 78 USPQ2d at 1335. Where all the elements of the claimed subject matter are found in separate pertinent references, there must be a motivation by the general problem facing the inventor that would have led to the combination of elements recited in the claims. *Id.* The Examiner has not articulated reasons why one skilled in the art would combine the

teachings of JP '492 with those of the primary references. The final Office Action only asserts that their teachings are consistent with their respective objectives. As detailed hereinafter, the Examiner has not made out a *prima facie* case of obviousness in combining JP '492 with the three primary references since there is no motivation disclosed in any of the references for including the melamine cyanurate that is disclosed in JP '492 with the flame retardant compositions disclosed in the Gallo patent, JP '347 or JP '396.

(1) **JP '492 does not teach a benefit of including a metal oxide with melamine cyanurate in a flame retardant composition.**

JP '492 discloses using organic flame retardants (with optional metal oxide flame retardants) in an epoxy resin composition. The reference only considers that certain inorganic fire retardants may be optionally included as components. These optional fire retardants may be metal oxides and metal hydroxides. Nowhere does the reference appreciate that a Group VIA transition metal oxide provides improved flame retardant characteristics.

Metal hydroxides function as flame retardants by decomposing and producing water when exposed to heat. A transition metal oxide does not accomplish such a function. Therefore, one skilled in the art would not be motivated to substitute the tungsten trioxide of Gallo with the optional metal hydroxide taught by JP '492.

The only metal oxide that is disclosed in JP '492 is nickel oxide, which is an oxide of a Group VIIB element. Nowhere does JP '492 suggest that including another component to the melamine cyanurate will result in a significantly improved flame retardant composition. Para. 23 of JP '492 explains that an excessive amount of organic flame retardant reduces heat resistance. The statement in the Office Action that JP '492 teaches "incorporating a melamine cyanurate together with a metal oxide in order to impart solder thermal resistance along with fire resistance" mischaracterizes its teachings. JP '492 teaches using a controlled amount of an organic flame retardant to maintain solder thermal resistance. It does not teach adding a metal oxide along with melamine cyanurate to impart solder thermal

resistance. The reference only indicates that inorganic fire retardant agents may be included as optional components of a fire retardant agent.

The Advisory Action of April 14, 2006 asserts that JP '492 provides motivation to incorporate melamine cyanurate with the WO<sub>3</sub> or MoO of Gallo, JP '347 or JP '396 "to impart high temperature reliability and solder heat resistance along with fire retardance" per page 9, paragraph 23 of JP '492. The translation of paragraph 23 of JP '492 reads in pertinent part:

The content of the fire retardant agent of which the main component is organic, should be 1~ 20 wt %, preferably 5 ~ 15 wt %, more preferably it should be in the range of 9 ~ 15 %, of the total semiconductor encapsulating resin composition. If this content is too low, the fire retardant effect is poor. On the other hand, if the content is too high, the high temperature reliability and the solder heat resistance tend to decrease.

That passage explains that insufficient organic agent lowers the fire retardant effect while excess organic agent decreases "high temperature reliability and solder heat resistance". It does not suggest that melamine cyanurate is suitable or desirable for including in a flame retardant composition already containing a transition metal oxide flame retardant. It only teaches that the amount of organic agent should be controlled.

The motive articulated by the Examiner for combining an organic fire retardant with metal oxides (to impart solder thermal resistance) is not presented by the references nor is there any reason provided that one skilled in the art would even consider solder thermal resistance as a motivating factor. In the absence of a motive to supplement the metal oxide flame retardants of the primary references (Gallo patent, JP '347 or JP '396) with the organic flame retardant of JP '492, a *prima facie* case of obviousness has not been established.

Accordingly, there is no suggestion to combine the organic agent of JP '492 with the flame retardant compositions of Gallo, JP '347 or JP '396. When

both types of flame retardant compositions are functional (transition metal oxide and organic agent), there is no motivation to supplement one with the other.

(2) **JP '492 demonstrates that melamine cyanurate alone is sufficient for providing flame retardant properties to an epoxy resin composition.**

The Examples and Comparison Examples of JP '492 elucidate this point. A verified translation of JP '492 was submitted in this application on April 5, 2006 and entered in the record pursuant to the Advisory Action of April 14, 2006. Examples 6 and 7 of JP '492 included both melamine cyanurate and inorganic fire retardant agents, namely,  $Mg(OH)_2$  and  $NiO$ . Examples 8 and 9 used only melamine cyanurate. See Table 1.

As reported in Table 3, there was no difference in the flame retardant properties between the tests reported for Examples 6 and 7 that included melamine cyanurate alone and the tests reported for Examples 8 and 9 (melamine cyanurate with inorganic fire retardant agents) with inorganic components. Moreover, the Examples without an inorganic component (8 and 9) exhibited generally better flow properties (150 and 230 poise vs. 200 and 250 poise) and identical solder thermal resistance to Examples 6 and 7 which used inorganic flame retardants.

Examples 6-9 of JP '492 show that the inorganic flame retardants provided insignificant benefit to the compositions. These results would suggest to one skilled in the art that melamine cyanurate alone is sufficient as a flame retardant and adding an inorganic flame retardant would not impact the composition significantly.

Contrary to these inconclusive results reported in JP '492 that a metal oxide ( $NiO$ ) has no significant effect on a flame retardant composition containing melamine cyanurate, Applicants have demonstrated a synergistic effect of using melamine cyanurate and a transition metal oxide as flame retardants in a molding composition. See Evidence Appendix, the Declaration Under 37 C.F.R. §1.132 submitted April 12, 2005.

The Examiner has not provided a properly reasoned basis to combine the teachings of JP '492 with those of the primary references as is required to

establish obviousness. *Kahn*, 441 F.3d at 987; 78 USPQ2d at 1335. Since JP '492 does not report any improvement achieved when melamine cyanurate is used in combination with nickel oxide as a flame retardant over melamine cyanurate alone, there is no motivation provided by any of the references for modifying the teachings of the Gallo patent or JP '347 or JP '396 to include melamine cyanurate along with the Group VIA transition metal oxides disclosed therein. The Gallo patent, JP '347 and JP '396 all already contain flame retardants in the form of Group VIA transition metal oxides. Nothing in JP '492 indicates or suggests any improved results that might occur if melamine cyanurate was included with a transition metal oxide. As such, claims 1-15 and 25-27 define over the combined teachings of the Gallo patent, JP '347, and/or JP '396 with JP '492.

**C. No motivation exists in the cited references for replacing the nickel oxide of JP '492 with the tungsten trioxide of Gallo or JP '347.**

In the rejection based on JP '492 as the primary reference, the Gallo patent and JP '347, the Examiner asserts that it would be obvious to use the WO<sub>3</sub> of Gallo and JP '347 as the "metal oxide" disclosed in JP '492. The asserted motivation is to improve the moisture resistance of the epoxy composition and to improve the balance between fire retardance and hardenability.

At col. 1, lines 28-32, Gallo states that phosphorous containing compounds are undesirable in that they tend to have a high moisture absorption rate. Hence, Gallo teaches at col. 5, lines 49-51 that transition metal oxides are substitutes for phosphorous containing compounds because they do not increase the rate of moisture absorption. The moisture resistance of Gallo comes from avoiding a phosphorous-containing compound. There is no motivation to substitute the NiO of JP '492 with the Gallo transition metal oxide since such a substitution of NiO by a transition metal oxide would not be made to replace a phosphorous compound to reduce moisture absorption. As such, replacing NiO with WO<sub>3</sub> would not improve moisture resistance of the epoxy composition.

Further, while both JP '492 and Gallo describe using some type of metal oxides, their teachings are not necessarily combinable without some motivation to do so. *Kahn*, 441 F.3d at 986; 78 USPQ2d at 1335.



The Examiner asserts that motivation for balancing fire retardance and hardenability is found in JP '347, which indicates that low amounts of MoO or ZnO reduce fire retardancy and higher amounts thereof negatively impact hardenability. This teaching in JP '347 does not suggest that WO<sub>3</sub> is a substitute for the NiO flame retardant disclosed in JP '492. It only indicates that the amount of transition metal oxide should be controlled at a particular level to control properties. The need to control the level of a transition metal oxide to balance composition properties does not mean that a transition metal oxide should be used to replace the NiO of JP '492. In fact, JP '347 indicates that the oxide may be an oxide of zinc, tin or transition metals, including molybdenum and tungsten. It does not suggest that a transition metal oxide is preferable over a metal oxide such as the nickel oxide disclosed in JP '492. As such, JP '347 gives no specific motivation to replace the NiO of JP '492 with a transition metal oxide. This mere opportunity to combine the teachings of JP '347 and JP '492 does not establish obviousness to do so. The Examiner has not established the desirability of modifying JP '492.

Again, while JP '347, the Gallo patent and JP '492 all relate to flame retardant compositions, in the absence of some motivation to alter the teachings of JP '492, the *prima facie* case of obviousness of claims 1-15 and 25-27 has not been established.

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### **VIII. CONCLUSION**

In view of the foregoing, reconsideration of the rejections of claims 1-15 and 25-27 is respectfully requested. Allowance of pending claims 1-15 and 25-27 is respectfully requested.

Respectfully submitted,

THE WEBB LAW FIRM

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**CLAIM APPENDIX**

1. A flame retardant molding composition substantially free of halogen, phosphorous and antimony, comprising:

an epoxy resin;  
melamine cyanurate; and  
a transition metal oxide of a Group VIA element.

2. The molding composition of claim 1, wherein the transition metal oxide is tungsten oxide.

3. The molding composition of claim 2, wherein the tungsten oxide is tungsten trioxide.

4. The molding composition of claim 1, further comprising a phenolic novolac hardener.

5. The molding composition of claim 4, wherein the amount of the phenolic novolac hardener ranges from about 1.5 weight % to about 10 weight % based on the total weight of the molding composition.

6. The molding composition of claim 1, wherein the epoxy resin comprises an epoxy cresol novolac resin.

7. The molding composition of claim 1, wherein the epoxy resin comprises a biphenyl epoxy resin.

8. The molding composition of claim 1, wherein the melamine cyanurate is present in an amount of from about 0.1 to about 3.5 percent by weight of the molding composition and the transition metal oxide is present in an amount from about 0.1 to about 2 percent by weight of the molding composition.

9. The molding composition of claim 1, wherein the amount of the epoxy resin ranges from about 4 weight % to about 12 weight % based on the total weight of the molding composition.

10. The molding composition of claim 9, wherein the amount of the epoxy resin ranges from about 5.5 weight % to about 8.5 weight % based on the total weight of the molding composition.

11. The molding composition of claim 1, further comprising a bulk amount of a filler material.

12. A flame-retardant molding composition substantially free of elemental halogen, phosphorous and antimony, comprising:

about 4 weight % to about 12 weight %, based on the total weight of the composition of an epoxy resin;

about 0.1 weight % to about 3.5 weight %, based on the total weight of the composition of melamine cyanurate;

about 0.1 weight % to about 2 weight %, based on the total weight of the composition of tungsten trioxide;

about 0.001 weight % to about 10 weight %, based on the total weight of the composition of a phenolic hardener; and

about 10 weight % to about 85 weight %, based on the total weight of the composition of a filler material.

13. The molding composition of claim 12, further comprising from about 0.1 weight % to about 10 weight %, based on the total weight of the composition, of one or more additives selected from the group consisting of colorants, mold release agents, coupling agents, catalysts, ion scavengers, metal oxides, metal hydroxides, pigments, adhesion promoters, toughening agents, UV absorbers, and antioxidants.

14. The molding composition of claim 12, wherein the epoxy resin comprises an epoxy cresol novolac resin.

15. The molding composition of claim 12, wherein the epoxy resin comprises a biphenyl epoxy resin.

16-24. (Cancelled).

25. The molding composition of claim 1, further comprising an anhydride hardener.

26. The molding composition of claim 25, wherein the amount of the anhydride hardener ranges from about 1.5 weight % to about 10 weight % based on the total weight of the molding composition.

27. A flame-retardant molding composition substantially free of elemental halogen, phosphorous and antimony, comprising:

about 4 weight % to about 12 weight %, based on the total weight of the composition of an epoxy resin;

about 0.1 weight % to about 3.5 weight %, based on the total weight of the composition of melamine cyanurate;

about 0.1 weight % to about 2 weight %, based on the total weight of the composition of tungsten trioxide;

about 0.001 weight % to about 10 weight %, based on the total weight of the composition of an anhydride hardener; and

about 10 weight % to about 85 weight %, based on the total weight of the composition of a filler material.

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### **EVIDENCE APPENDIX**

Appellants submit herewith:

(1) a copy of the April 11, 2005 Declaration Under 37 C.F.R. §1.132 submitted April 12, 2005 and entered in the record pursuant to the Office Action of May 9, 2005.

(2) a copy of the certified translation of Japanese Patent No. 11-100492 submitted with the Request for Reconsideration After Final Rejection dated February 24, 2006 and entered in the record pursuant to the Advisory Action of April 14, 2006.

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**RELATED PROCEEDING APPENDIX**

None.



Application No. 10/644,791  
Reply to Office Action of January 13, 2005  
Attorney Docket No. 3833-030392 (LDEO-108)

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Application No. : 10/644,791 Confirmation No. 7402  
Applicants : Anthony A. Gallo et al.  
Filed : August 19, 2003  
Title : Flame Retardant Molding Compositions Containing Group  
VIA Metal Oxides  
Group Art Unit : 1712  
Examiner : Christopher M. Keehan

**DECLARATION UNDER 37 C.F.R. §1.132**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

I, Anthony A. Gallo, one of the named inventors of the invention described and claimed in the above-identified patent application, hereby declare and state as follows:

1. I am a graduate of Union College, Schenectady, New York, 1964, with a B.S. degree in Chemistry. I have a Ph.D. in Organic Chemistry, which I received from Tufts University, Medford, MA, in 1969. I have over 30 years of industrial experience in organic chemistry, in the positions noted in Appendix A.

2. I am an author on the publications listed in Appendix B.

3. I am a named inventor on the patents listed in Appendix C. I have an inventor's understanding of the patent system, and I participated in the preparation of the present application. I have read the Office Action and the references cited by the Examiner in the Action, Ogura et al. (US 6,660,811), Gallo et al. (US 5,476,716), von Gentzkow et al. (US 5,760,146) and Heine et al. (US 6,500,546).



4. Under my direction and control, additional experiments were carried out with the sample molding compositions set forth in Table 1 of the present Declaration to specifically address the Examiner's concerns in the previous Office Action. Ten (10) parts of the combination tungsten trioxide and melamine cyanurate were compared to 10 parts tungsten trioxide alone and 10 parts melamine cyanurate alone. These compositions were subjected to the UL94 flammability, gel time and shelf life stability tests as described in the application at pages 11-12. The results of these tests are presented in Table 1 of this Declaration.

5. The data presented in Table 1, in the row designated as Flammability (Set 1 and Set 2) is derived as follows: the flame time after each ignition of a bar is recorded. If the flame time exceeds about 20 seconds, "totally burned" ("tb") is recorded. Each bar is ignited twice, and the total flame time for each bar is added to give the total burn time. Thus, looking at Set 1 data, the 5 bars for Sample A had total burn times of 4, 6, 3, 5 and 7, for a total of 25, whereas the five bars for Sample B were all totally burned. The material of Sample C was not flowable and therefore could not produce parts for testing. The UL94V-O standard requires that the total burn time for each bar not exceed 10 seconds, and that the total for five bars not exceed 50 seconds.

6. As can be seen in Table 1, the composition containing both tungsten trioxide and melamine cyanurate (Sample A) had substantially improved flame retardance as compared to the samples having tungsten trioxide alone (Sample B) or melamine cyanurate alone (Sample C). Sample A more than meets the UL94V-O standard, while the other two samples do not.

7. It is my well-reasoned opinion that the results presented in Table 1 could not have been predicted, based on the teachings of the references cited in the Office Action.

Ogura does not teach the use of a combination of compounds to provide flame retardance, and does not teach the specific combination claimed in the present invention, namely, melamine cyanurate and a Group VIA transition metal oxide such as tungsten oxide. It is my opinion that the present invention is not obvious in view of Ogura alone or Ogura in combination with Gallo, which is merely cited for the teaching of tungsten trioxide. Gallo also does not teach the specific combination of flame retardant compounds used in the present invention. This combination is also not obvious in view of Gallo combined with von Gentzkow or Heine.

TABLE 1

	SAMPLE A	SAMPLE B	SAMPLE C
Silica fillers	69.59	69.59	69.59
Bis-phenol-A type epoxy resin	6.02	6.02	6.02
Solid epoxy cresol novolac resin	7.34	7.34	7.34
Benzophenone dicarboxylic acid dianhydride	4.85	4.85	4.85
Tungsten trioxide	6.00	10.00	0.00
Melamine cyanurate	4.00	0.00	10.00
Black coloring agents	0.40	0.40	0.40
Zinc benzimidazole catalyst	0.10	0.10	0.10
Wax release agents	0.50	0.50	0.50
Silane coupling agent	1.20	1.20	1.20
Total	100.00	100.00	100.00
Gel @177°C/sec	24	26	17
Flow	34.66	38.66	12.66
Flammability, 1/8"			
Set 1	0, 0, 0, 0, 0	0, 0, 0, 0, 0	*
Set 2	4, 6, 3, 5, 7	tb, tb, tb, tb, tb	*

tb = total burn

\* = Flow too short where the material not workable to produce parts to test.

8. I declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so

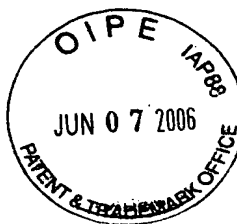
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made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed Name: Anthony A. Gallo

Typed Name: Anthony A. Gallo

Date: 4/11/05



EXPERIENCE:

- 1997 - Present      Research Scientist, Dexter Electronic Materials Division of the Dexter Corporation, Olean, NY. Formulated "Green" Molding Compounds.
- 1992 - 1997        Research Associate, Dexter Electronic Materials Division of the Dexter Corporation, Olean, NY. Formulated Semiconductor Molding Powders. Developed "popcorn" resistant molding compounds.
- 1988 - 1992        Project Leader, Dexter Electronic Materials Division of the Dexter Corporation, Olean, NY. Formulated Semiconductor Molding Powders. Developed a patented additive to protect against intermetallic corrosion.
- 1980 - 1988        Senior Chemist, Dexter Electronic Materials Division of the Dexter Corporation, Olean, NY. Developed new method for improved Silazanes (two patents granted). Supervised two technicians in their preparation, analysis, and field testing.
- 1978 - 1980        Senior Chemist, Frekote, Inc., Indianapolis, Indiana. Developed hands-on experience in reacting silicone oils and resins and formulating these materials into finished release products.
- 1971-1978         Senior Instructor, Department of Biochemistry, School of Medicine, Case Western Reserve University. Performed classroom teaching, prepared scientific articles, and gave presentations at technical meetings.
- 1969 - 1971        Postdoctoral Fellow, Department of Biochemistry, School of Medicine, Case Western Reserve University. Performed NMR research on Vitamin B<sub>1</sub>.

PUBLICATIONS:

- (1) "Hydroxyl Proton Coupling in Cyclohexanols, Rotamer Populations of the Hydroxyl Group," R.D. Stolow and A.A. Gallo, *Tetrahedron Letter*, pp. 3331-3336 (1968).
- (2) "Destabilization of chair Conformations of Cyclohexanones by t-Butyl-Hydroxyl and t-Butyl-Methoxyl Gauch Interactions," R.D. Stolow, A.A. Gallo and J.L. Marini, *Tetrahedron Letters*, pp. 4655-4658 (1969).
- (3) "Magnetic Resonance Study of the  $Mn^{2+}$  Lysozyme Complex," A.A. Gallo, R.J. Swift, and H.Z. Sable, *Biochem. Biophys. Res. Comm.* 43, 1232-1238 (1971).
- (4) "Proton Magnetic Resonance Studies of Complexes of Thiamin Pyrophosphate with Divalent Cations," A.A. Gallo, I.L. Hansne, H.Z. Sable, and T.J. Swift, *J. Biol. Chem.* 247, 5913-5920 (1972).
- (5) "Rate Enhancement of Pyruvate Aldolization by Divalent Cations: A Model for Class 2 Aldolases," A.A. Gallo and H.Z. Sable, *Biochem. Biophys. Acta* 302, 443-456 (1973).
- (6) "Carbon 13 Nuclear Magnetic Resonance Studies of DL-2-( $\alpha$ -hydroxyethyl) Thiamin and Related Compounds," A.A. Gallo and Y.Z. Sable, *J. Biol. Chem.* 251, 2564-2570 (1976).
- (7) "Confirmation of Complexes of Thiamin Pyrophosphate with Divalent Cations as Studies by Nuclear Magnetic Resonance Spectroscopy," A.A. Gallo and H.Z. Sable, *J. Biol. Chem.* 250, 49896 (1975).
- (8) "Analogues of Natural Lipids III. Non equivalence of Methyl groups in Methylated Phospholipids," A.A. Gallo, A.J. Hancock, and H.Z. Sable, *J. Lipid Research* 18, 77-80 (1977).
- (9) " $^{13}C$ -NMR Relaxation of Trilaurin," A.A. Gallo, *FEBS Letters*, 81, 97-99 (1977).
- (10) "Structural and Mechanistic Aspects of Catalysis by Thiamin," A.A. Gallo, J.J. Mieyal and H.Z. Sable, *Biorganic Chemistry*, Vol. 4, Chapter 5, E.E. Van Tamelen ed., Academic Press (1978).
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(54) [Title of the Invention]

**Resin Composition for Encapsulating Semiconductors, and the Semiconductor Device That Uses this Composition.**

(57) [Summary]

**[Objective]**

To offer the semiconductor device that uses the resin composition for encapsulating the semiconductor which has not only safety properties but which also has excellent soldering heat resistance and high temperature reliability.

**[Method to Achieve the Objective]**

The semiconductor is encapsulated by using the semiconductor- encapsulating- resin



composition that is comprised of the below listed components (2) ~ (9), in which the content of the fire retardant agent (9), of which the main component is the organic fire retardant agent, is 1 ~ 20 wt % of the total of the said resin composition.

(2) Thermosetting resin

(I) Curing agent

(9) Fire retardant agent of which the main component is an organic fire retardant agent.

### **[Scope of the Patent Application]**

#### **[Claim 1]**

Semiconductor- encapsulating- resin composition that is comprised of the following components (2) ~ (9).

(2) Thermosetting resin

(I) Curing agent

(9) Fire retardant agent of which the main component is an organic fire retardant agent.

#### **[Claim 2]**

Semiconductor- encapsulating- resin composition characterized by the fact that the content of the fire retardant agent (9), of which the main component is the organic fire retardant agent, is 1 ~ 20 wt % of the total of the said resin composition, in the semiconductor encapsulating resin composition described in Claim 1.

#### **[Claim 3]**

Semiconductor encapsulating resin composition in which the organic fire retardant agent is a hetero cyclic compound, as was described in Claim 1 or Claim 2.

#### **[Claim 4]**

Semiconductor encapsulating resin composition in which the thermal degradation initiation temperature of the organic fire retardant agent is 260 °C or higher, as was described in any one of Claims 1 to 3.

**[Claim 5]**

Semiconductor encapsulating resin composition in which the content of chlorine ions in the cured body is 200  $\mu\text{g}$  or less per 1 g of cured body, as was described in any one of Claims 1 to 4.

**[Claim 6]**

Semiconductor encapsulating resin composition in which the cured body of the semiconductor encapsulating resin composition shows the fire retardant ability equivalent to V-0 in the UL burning test with a thickness of 1/16 inch, as was described in any one of Claims 1 to 5.

**[Claim 7]**

Semiconductor device made by encapsulating the semiconductor using the semiconductor encapsulating resin composition described in any one of Claims 1 to 6.

**[Detailed Explanation of the Invention]**

**[0001]**

**[Technical Field in Which this Invention Belongs]**

This invention relates to the semiconductor encapsulating epoxy resin composition with excellent fire retarding ability, excellent solder heat resistance and excellent high temperature reliability, and also the semiconductor device that uses this resin.

**[0002]**

**[Existing Technology]**

Semiconductor elements such as transistors, ICs, LSIs, etc., used to be encapsulated by ceramic and they used to be made into semiconductor devices, however, recently, from the view point of the cost and the mass production ability, resin encapsulation that uses epoxy resin is becoming mainstream. By the way, the electronic parts such as the semiconductor devices, etc., must meet the UL 94 V-0 standard for fire retardation. Until now, as the method to add the fire retardant ability to the semiconductor encapsulating

epoxy resin composition, brominated epoxy resins and antimony oxide have been added generally, but the semiconductor devices that use this method have the following problems. Toxic gases such as hydrogen bromide, bromine, brominated antimony, etc., are generated during the burning time, and in addition, when it is left for a long time at high temperature, the aluminum wiring of the semiconductor element can be corroded by the free bromine that is generated, and the degree of high reliability decreases. Also, the method to use a metal hydroxide as the fire retardant agent has been suggested, but the semiconductors that use this method have the following problems too. The first problem is a decrease in the soldering heat resistance when surface-mounting the semiconductor. Namely, when the semiconductor device is exposed to high temperature (normally 215 ~ 260 °C) due to the treatment of submersion soldering, infrared reflow, vapor phase reflow, etc., the water that was retained in the metal hydroxide is suddenly vaporized, and by this, the semiconductor device experiences expansion or cracking, therefore, the soldering heat resistance decreases. The second problem is that the semiconductor element function in a high temperature environment of 150 ~ 200 °C decreases, namely the high temperature reliability decreases. Namely, in the semiconductor element with large heat generation or in the semiconductor device that is used in a high temperature environment, the de-watering reaction of the metal hydroxide occurs as a result of long time use, and the high temperature reliability decreases.

**[0003]**

Therefore, in order to solve the problems like these, the applicant of this invention had suggested the semiconductor encapsulating thermosetting resin composition that use both metal hydroxide and metal oxide as the fire retardant agent, and they have improved the safety, the soldering heat resistance and the high temperature reliability of the resin-encapsulated semiconductor device by using the said resin composition. (ATokuhyo@H7-806085 Official Gazette)

**[0004]****[Problem That this Invention Intends to Solve]**

However, accompanying the recent development of technology in the semiconductor

field, even better soldering heat resistance and high temperature reliability have been desired, and even the semiconductor encapsulating thermosetting resin composition that uses the fire retardant agent that co-uses both the above mentioned metal hydroxide and metal oxide, is not sufficiently reliable for some semiconductor elements. Also, in the case when a metal hydroxide is used as the fire retardant agent, or in the case when a metal hydroxide and a metal oxide are used, the flow ability of the semiconductor encapsulating resin composition during the forming time decreases, and depending on the shape of the semiconductor package, the forming becomes impossible. This invention was made based on this situation, and the objective is to offer the semiconductor encapsulating resin composition with excellent fire retardant ability, excellent soldering heat resistance, excellent high temperature reliability, excellent forming ability and safety, and also the semiconductor device that uses this.

**[0005]****[Method to Solve the Problem]**

The inventors investigated and discovered that if an organic fire retardant agent is used as the main component of the fire retardant agent, not only can solder heat resistance and high temperature reliability be obtained, but also the good forming ability can be obtained, and this invention was made.

**[0006]**

Namely, this invention is the semiconductor- encapsulating- resin composition that is comprised of the following components (2) ~ (9).

(2) Thermosetting resin

(1) Curing agent

(9) Fire retardant agent of which the main component is an organic fire retardant agent.

**[0007]**

Also, this invention is the semiconductor device which is made by encapsulating the semiconductor element using the above mentioned semiconductor encapsulating resin composition.

**[0008]**

**[Form of Bringing this Invention into Practice]**

Next, the form to bringing this invention into practice will be explained in detail.

**[0009]**

The semiconductor encapsulating resin composition of this invention can be obtained from the thermosetting resin (component 2), the curing agent (component []) and the fire retardant agent (component 9) of which the main component is an organic fire retardant agent, and normally, it is in the form of a powder or a tablet.

**[0010]**

As the above mentioned thermosetting resin (component 2), epoxy resin, poly maleimide resin, unsaturated polyester resin, phenolic resin, etc., can be listed. Especially, in this invention the use of epoxy resin and poly maleimide resin is preferred.

**[0011]**

The above mentioned epoxy resin is not particularly limited, and the already known ones can be used. For instance, the bisphenol A type, the phenolic novolac type, the cresol novolac type, the biphenyl type, the phenylene type, etc., can be listed.

**[0012]**

The above mentioned poly maleimide resin is not particularly limited, and already known ones that have 2 or more maleimide groups in their molecule can be used. For instance, N, N=-4, 4'- di-phenyl methane bis maleimide; 2, 2-bis-[4-(maleimide phenoxy) phenyl] propane, etc., can be listed.

**[0013]**

As the curing agent (component []) that is used with the above mentioned thermosetting resin (component 2), the already known ones, for instance the phenolic resins, acid anhydrides, amine compounds, etc., can be used. In the case when an epoxy resin is

used as the above mentioned thermosetting resin, a phenolic resin should be used suitably. Phenolic novolac resin, cresol novolac resin, bisphenol A type novolac resin naphthol novolac resin and phenol aralkyl resin, etc., can be listed as the above mentioned phenolic resins.

#### [0014]

Also, the curing agent when poly maleimide is used as the thermosetting resin is not particularly limited and the already known ones can be used. For instance, the alkenyl phenols which can be obtained by reacting the above mentioned epoxy resin curing agent in the presence of an allyl halide and an alkali, or amines can be listed.

#### [0015]

In the case when the above mentioned thermosetting resin (component 2) is epoxy resin, and the above mentioned curing agent (component []) is phenolic resin, the content proportions of these should be set preferably in the way that the hydroxyl group content of the phenolic resin becomes 0.7 ~ 1.3 equivalents for 1 equivalent of the epoxy groups in the above mentioned epoxy resin, and more preferably it should be set to equal 0.9 ~ 1.1 equivalents.

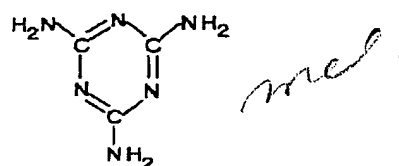
#### [0016]

In this invention, the fire retardant agent of which the main component is an organic fire retardant agent is used with the thermosetting resin (component 2) and the curing agent (component []). Here, in this invention, the fire retardant agent of which the main component is an organic fire retardant agent, includes the ones which are comprised of only a organic fire retardant agent too. The content of the organic fire retardant agent in the fire retardant agent should be preferably 95 ~ 100 wt %. Hetero cyclic compounds, nitrogen- containing compounds, phosphorus- containing compounds, etc., can be listed as the organic fire retardant agents, and the hetero cyclic compounds are especially preferred for use. Concerning the hetero cyclic compound, for instance the hetero cyclic compounds that have a tri azine ring such as melamine (shown by Chemical Formula 1) or cyanuric acid (shown by Chemical Formula 2), the derivatives of cyanuric acid such as

iso cyanuric acid (shown by Chemical Formula 3) or melamine cyanurate (shown by Chemical Formula 4), etc., and the compounds that have a phosphazene ring (shown by, for instance Chemical Formula 5), etc., can be listed. These can be used alone or in combinations of 2 or more.

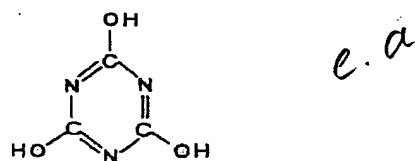
[0017]

[Chemical Formula 1]



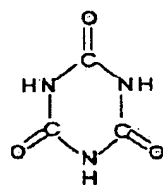
[0018]

[Chemical Formula 2]



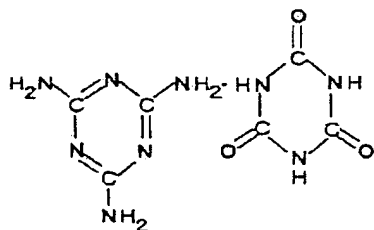
[0019]

[Chemical Formula 3]



[0020]

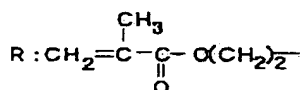
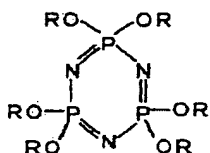
[Chemical Formula 4]



*mel.  
cyanurate*

[0021]

[Chemical Formula 5]



[0022]

Concerning fire retardant agents other than organic ones, inorganic fire retardant agents such as metal oxides, metal hydroxides, etc., can be used at 0 ~ 5 wt % of the fire retardant agent.

[0023]

The content of the fire retardant agent of which the main component is organic, should be 1 ~ 20 wt %, preferably 5 ~ 15 wt %, more preferably it should be in the range of 9 ~ 15 %, of the total semiconductor encapsulating resin composition. If this content is too low, the fire retardant effect is poor. On the other hand, if the content is too high, the high temperature reliability and the solder heat resistance tend to decrease.

[0024]

The temperature at which the thermal degradation of the above mentioned organic fire retardant agent begins should be preferably 260 °C or higher (normally, the upper limit is 500 °C). If the thermal degradation initiation temperature is less than 260 °C, thermal



degradation starts sooner than the thermal degradation of the organic components other than the organic fire retardant agent that are included in the semiconductor encapsulating resin composition of this invention, therefore the fire retardant ability decreases. Here, the thermal degradation initiation temperature of the organic fire retardant agent is the value that is measured by thermogravimetric analysis that uses a thermobalance with a temperature increase rate of  $10^{\circ}\text{C} / \text{min}$ , and it is whichever is the lower temperature of the temperature at which the weight loss reaches 5 wt %, and the temperature at which the differential weight loss value (the value where weight loss is first order differentiated in time, namely the rate of weight loss) exceeds 0.5 wt %.

#### [0025]

Concerning the semiconductor encapsulating resin composition that includes the fire retardant agent of which the main component is the above mentioned organic fire retardant agent, preferably the chlorine ion content that is extracted in the following manner should be  $200\ \mu\text{g}$  or less for 1 g of the cured body of the above mentioned resin composition. Namely, 5 g of the cured body of the resin composition and 50 cc of distilled water are put into a simple autoclave, and this autoclave is left in a drying oven at  $160^{\circ}\text{C}$  for 20 hours, and the extraction water is obtained (the pH should be in the range of 6.0 ~ 8.0). This extraction water is analyzed by ion chromatography, and the amount of chlorine ions (X) is measured. This chlorine ion content (X) is the value where the ions in the cured body of the resin composition are diluted 10 times, therefore, the chlorine ion content per 1 g of the resin composition cured body is calculated by the following equation.

#### [0026]

Chlorine ion content ( $\mu\text{g}$ ) per 1 g of the resin composition cured body =  $X \times (50/5)$

#### [0027]

Namely, if the chlorine ion content included in 1 g of the resin composition cured body is higher than  $200\ \mu\text{g}$ , corrosion of the semiconductor element or leads might occur, and the moisture resistance reliability tends to decrease.

**[0028]**

In order to make the chlorine ion content included in 1 g of the resin composition cured body to be less than 200  $\mu\text{g}$ , the chlorine ions in the above mentioned organic fire retardant agent should be preferably 50 ppm per 1 g. Here, the chlorine ion content in the organic fire retardant agent can be obtained by replacing the resin composition cured body with the organic fire retardant agent, in the above mentioned method for measuring the chlorine ion content in the cured body of the resin composition.

**[0029]**

The semiconductor encapsulating thermosetting resin composition of this invention can include an inorganic filler, a curing promotion agent, pigments, a mold separating agent, a flexibility adding agent, etc., in addition to the above mentioned (2) ~ (9), depending on necessity.

**[0030]**

Quartz glass powder, talc, silica powder, alumina powder, calcium carbonate, etc., can be listed as the inorganic fillers. Especially, the use of silica powder is suitable.

Concerning the content of the inorganic fillers, in the case of silica powder, it is preferred to make the total amount of the inorganic filler, inorganic fire retardant agent and the organic fire retardant agent to be 60 wt % or greater of the entire resin composition. More preferably it should be 70 wt % or greater (normally the upper limit is 93 wt %). Namely, if the content of total inorganic material is less than 60 wt %, the fire retardant ability tends to decrease.

**[0031]**

Concerning the above mentioned curing promotion agent, the already known materials, for instance, 1, 8-di-aza-bicyclo (5, 4, 0) undecene-7; tertiary amines such as tri ethylene diamine, etc.; imidazoles such as 2- methyl imidazole, etc.; phosphorus type curing promotion agents such as the tri phenyl phosphine, tetra phenyl phosphonium tetra phenyl borate, etc., can be listed.

**[0032]**

Carbon black, titanium oxide, etc., can be listed as the above mentioned pigment.

**[0033]**

Concerning the mold separation agent, poly ethylene wax, paraffins, or fatty acid esters, fatty acid salts, etc., can be listed.

**[0034]**

Concerning the flexibility adding agent, coupling agents such as silane coupling agents, etc., silicone resins, and the butadiene - acrylonitrile rubber, etc., can be listed.

**[0035]**

The semiconductor encapsulating resin composition of this invention can be produced for example, as follows. Namely, the thermosetting resin (component 2), the curing agent (component []) and the fire retardant agent (component 9) of which the main component is an organic fire retardant agent, and other additives if necessary, are blended in the prescribed proportions. Then, this mixture is melt-kneaded with heating by using a kneader such as a mixing roll machine, etc., and then it is cooled to room temperature. Then this is crushed by an already known method, and if necessary, it is made into tablets. By this series of processes, the objective resin composition can be produced. The method for encapsulating the semiconductor element is not particularly limited, and it can be done by an already known method such as ordinary transfer forming, etc.

**[0036]**

Next, Actual Examples and Comparisons will be explained.

**[0037]**

**[Examples 1 ~ 9, and Comparisons 1 ~ 3]**

Each of the components shown in Tables 1 and 2 was blended in the proportions listed,

and it was melt- kneaded for 3 minutes with a mixing roll (100 °C), and after it was cooled down, it was crushed, and the thermosetting resin composition was obtained in powder form. Among the above mentioned components, the thermal degradation initiation temperature of the melamine, cyanuric acid and melamine cyanurate that were used as the organic fire retardant agent were 270 °C, 310 °C and 320 °C, respectively. Using the thermosetting resin compositions obtained in the Examples and Comparisons, the semiconductor element was transfer- formed (conditions : 175 °C x 2 minutes), and it was post-cured at 175 °C x 5 hours, and thus, the semiconductor device was obtained. This semiconductor device was an 80 pin QFP (quad flat pack, size : 20 x 14 x 2 mm), and the "di pad" (*phonetically written*) size was 8 x 8 mm. The semiconductor device obtained like this was left in a high temperature tank at 85 °C / 85 % relative humidity for 96 hours to absorb the moisture, and thereafter, it was infrared reflowed for 90 seconds at a heating temperature of 240 °C, and the soldering heat resistance was evaluated. Also, the above mentioned semiconductor device was left at 200 °C, and the time at which the failure rate became 50 % was measured, and this was used for the evaluation of the high temperature reliability. In addition, the test specimen with a thickness of 1/16 inch was formed, and the fire retardant ability was evaluated according to the UL 94 V-0 standard. Also, the resin composition cured body was crushed, and using this as the sample, the thermal degradation initiation temperature of the resin composition cured body was measured by the above mentioned method. Also, the content of chlorine ions per 1 g of cured body of the resin composition was measured according to the above mentioned method. Also, the spiral flow value and the flow tester viscosity were measured as the indicators of the forming ability of the resin composition. These results are shown in Table 3 and Table 4.

[0038]

[Table 1]

		Actual Example								
		1	2	3	4	5	6	7	8	9
Epoxy resin (weight parts)	Cresol novolac type	63.8			63.8	63.8		63.8	63.8	63.8
	Biphenyl type		51.8	51.8			51.8			
Phenolic resin (weight parts)	Novolac type	34.2			34.2	34.2		34.2	34.2	34.2
	Aralkyl type		46.2	46.2			46.2			
Organic fire retardant agent (weight parts)	Melamine	50			70					
	Cyanuric acid		50			70				
	Melamine cyanurate			80			100	70	50	120
Inorganic fire retardant agent (weight parts)	Mg (OH) <sub>2</sub>				3	2	1	0.5		
	NiO					1	0.5	0.5		
Silica (weight parts)		199	349	559	339	455	499	799	799	399
Phosphorus type curing promoting agent (weight parts)		1	1	1	1	1	1	1	1	1
Ester type wax (weight parts)		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Olefin type wax (weight parts)		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Carbon black (weight parts)		1	1	1	1	1	1	1	1	1
Total (weight parts)		350	500	740	513	629	701.5	971	950	620
Content of organic fire retardant agent in fire retardant agent (wt %)		100.00	100.00	100.00	95.89	95.89	98.52	98.59	100.00	100.00
Content of fire retardant agent in the entire resin composition ( wt %)		14.3	10.0	10.8	14.2	11.6	14.5	7.3	5.3	19.4
Total content of fire retardant agent and inorganic filler in entire resin composition (wt %)		71.1	79.8	86.4	80.3	83.9	85.6	89.6	89.4	83.7

[0039]

[Table 2]

		Comparisons		
		1	2	3
Epoxy resin (weight parts)	Cresol novolac type		63.8	63.8
	Biphenyl type	51.8		
Phenolic resin (weight parts)	Novolac type		34.2	34.2
	Aralkyl type	46.2		
Organic fire retardant agent (weight parts)	Melamine			
	Cyanuric acid	200		
	Melamine cyanurate		2	
Inorganic fire retardant agent (weight parts)	Mg (OH) <sub>2</sub>			50
	NiO			
Silica (weight parts)		459	409	349
Phosphorus type curing promoting agent (weight parts)		1	1	1
Ester type wax (weight parts)		0.2	0.2	0.2
Olefin type wax (weight parts)		0.8	0.8	0.8
Carbon black (weight parts)		1	1	1
Total (weight parts)		760	512	500
Content of organic fire retardant agent in fire retardant agent (wt %)		100.00	100.00	0.00
Content of fire retardant agent in the entire resin composition ( wt %)		26.3	0.4	10.0
Total content of fire retardant agent and inorganic filler in entire resin composition (wt %)		86.7	80.3	79.8

[0040]

[Table 3]

	1	2	3	4	5	6	7	8	9
	acid	mel	MA	OH + mel	acid, OH, NiO	MA + OH, NiO	MA		
Solder heat resistance (Crack occurring ratio in the Infrared reflow test) (pieces / 10 pieces)	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
High temperature reliability (50 % failure occurring time at 200 °C) (h)	700	700	800	800	700	700	700	700	700
Fire retardant ability (UL94 V-0)	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Thermal degradation starting temperature of cured body of resin composition (°C)	300	290	290	300	300	290	300	300	300
Chlorine ion (μg) in 1 g of cured body of resin composition	40	10	35	40	15	45	30	20	30
Spiral flow value (cm)	95	90	100	90	100	80	80	90	80
Flow tester viscosity (poise)	100	90	110	250	200	200	250	150	230

[0041]

[Table 4]

	Comparison		
	1	2 MC	3
Solder heat resistance (Crack occurrence ratio in the Infrared reflow test) (pieces / 10 pieces)	5/10 X	0/10	2/10 X
High temperature reliability (50 % failure occurring time at 200 °C) (h)	300	500	500
Fire retardant ability (UL94 V-0)	Pass	Fail X	Fail X
Thermal degradation starting temperature of cured body of resin composition (°C)	300	290	300
Chlorine ion (μg) in 1 g of cured body of resin composition	20	10	150
Spiral flow value (cm)	90	100	60
Flow tester viscosity (poise)	90	110	300 X

[0042]

## [Effect of the Invention]

As was described above, in the semiconductor device of this invention, the semiconductor element is encapsulated by using the resin composition that contains the fire retardant agent of which the main component is an organic fire retardant agent. Therefore, compared with the case when a metal hydroxide is used as the fire retardant agent, or the case when a metal hydroxide and a metal oxide are co-used, the effect of water is extremely small, therefore, the solder heat resistance and the high temperature reliability improve, and it exhibits a long life. In addition, the fire retardant agent of which

the main component is an organic fire retardant agent, does not decrease the flow ability of the semiconductor encapsulating resin composition compared with metal hydroxides and metal oxides, therefore, the semiconductor encapsulating resin composition of this invention can exhibit good forming ability for any shape of semiconductor package. In addition, the semiconductor resin composition of this invention and the semiconductor device that uses this, have fire retardant ability without using a toxic halogen compound or antimony trioxide, therefore, it is extremely safe and environmentally friendly.

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